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CHAPTER 7: LANDSCAPE RESTORATION

7.1 CHAPTER GOALS

The primary goal of revegetation is the reclamation and stabilization of disturbed soils for the purposes of erosion control, improved aesthetics and the restoration of natural resources. Both BLM and FS consider the success of this work to be critical to the project. In addition, the revegetation of disturbed soils is a legal requirement imposed by EPA/ADEQ, which enforce the National/Arizona Pollutant Discharge Elimination System (NPDES/AZPDES) (see Chapter 8).

The primary goals of this chapter are to:

- Describe the issues relating to native vegetation that are critical to the visual integration of the highway corridor with the surrounding landscape.
- Describe the steps necessary to achieve successful revegetation of disturbed soils.

The ADOT Roadside Development Section and its consultant landscape architects typically assume responsibility for revegetation requirements in the project contract documents. Other specific aspects of highway design for which Roadside Development and landscape architects are typically responsible include aesthetic decisions regarding engineered slopes, bridges, walls, drainage structures, stormwater controls and safety barriers. The reader is referred to the chapters in this manual that describe these features in greater detail.

7.2 SCOPING AND NEPA PROCESSES

In general, for highways constructed on BLM or FS lands, the project team should seek to integrate the highway corridor with the surrounding natural landscape. The success of this integration depends largely on the scoping document which will, in turn, inform much of the design process. Therefore, the project team should carefully and fully explore implications to design that are contained in the scoping document. Issues that are typically addressed in the scoping document that will affect the integration of the highway with the surrounding landscape (and that are described in greater detail in other chapters) include:

- **Alignment:** Because the reclamation and stabilization of disturbed soils is critical, the project team should consider alignments that will minimize the sizes of cut and fill slopes. Large slopes are more prone to erosion and more difficult to revegetate than smaller slopes. This concern is particularly important where projects will be constructed in hilly or mountainous areas (see Chapter 4).
- **Existing vegetation:** The project team should determine the presence of any outstanding or unusual native trees, riparian vegetation or other existing native plants that warrant special consideration and review alignments or structures that will minimize impacts to those areas (see Chapters 4, 5 and 6).

7.3 DESIGN

Existing Vegetation

Protect existing trees and natural vegetation within the project limits in order to minimize the visual impact of the new improvements. Preserving existing vegetation, Figure 7.1, will also reduce the amount of disturbed soil exposed to erosive forces.

- Protect existing vegetation from equipment by staking, flagging and/or fencing. Establish tree-damage penalties in the construction documents.

Figure 7.1 Preserving existing vegetation.

Figure 7.2 Undulating edges break up an unnatural appearance.

Figure 7.3 Feathered by plant density and gradation.

- Within the limits of disturbance, trees with outstanding value and/or character may be preserved by means of retaining walls.
- Protect existing vegetation from blasting damage by controlling sizes of explosive charges and through the use of temporary earth berms and/or blankets. Establish tree-damage penalties in the construction documents.
- Protect existing vegetation in natural drainages by minimizing changes to natural flow dynamics.

Considerations that may direct the design team to remove existing vegetation include:

- Trees and shrubs whose roots will be significantly damaged by new cut slopes.
- Trees that may be downed by wind.
- Sight distance requirements.
- Species tolerance for anticipated road conditions.
- Trees that are diseased or in poor condition.
- Maintenance access to the tops of cut slopes and toes of fill slopes.
- Snow storage.
- Pullouts for vistas to scenic areas.
- Trees that will create hazardous winter shading.
- The presence of noxious or invasive weed species within the project limits (see below).

In heavily forested project areas, the design team should consider reducing the contrast between cleared and undisturbed areas in the following ways:

- Create an undulating cleared edge, Figure 7.2. Doing so will break up the unnatural appearance of a straight line and create a series of enclosures and openings.
- Feather the cleared edge by both reducing plant density and creating a gradation of low to tall vegetation, Figure 7.3, in a transition zone. When selecting vegetation for removal, consider the following:
  - Trees that may fall into the roadway if they remain on site.
  - Understory shrubs that may not survive if the tree canopy is removed.
  - Plants that cannot tolerate snow-removal chemicals.

Review the project limits for the presence of noxious and invasive weed species and treat as described in Chapter 11. In heavily forested areas, be aware that some invasive species will respond aggressively to tree removal and greater sunlight.

Disposal Methods for Vegetation

All road construction produces vegetative debris and the methods of disposal are typically described in the project contract documents. On-site disposal strategies include:

- Vegetation may be piled and burned and/or burned with an incinerator.
- Vegetation may be shredded or chipped for use as mulch on project slopes.
- The smaller, more easily decomposed leaves, needles, small branches, etc. may be salvaged and stockpiled with salvaged topsoil (discussed below). Prior to distributing this material over the surfaces of finished slopes, the combined vegetation and topsoil can be bermed at the toes of embankment slopes to form temporary erosion control berms. The designer should review this strategy for potential fire hazard.

- Vegetation can be buried.

Off-site disposal methods include removal to an approved disposal site. In forested areas, merchantable timber may be produced (see Chapter 2).

Revegetation

The primary goal of revegetation is the reclamation and stabilization of disturbed soils for the purposes of erosion control, improved aesthetics and the restoration of natural resources. Both BLM and FS consider the success of this work to be critical to the project. In addition, revegetation of disturbed soils is a legal requirement imposed by EPA/ADEQ, which enforce the National/Arizona Pollutant Discharge Elimination System (NPDES/AZPDES) (see Chapter 8). Because the success of the revegetation effort depends on weather conditions that are outside human control, it is important to optimize chances for success by close attention to the following:

- ***Slope ratios***
  In general, flatter slopes will revegetate more successfully than steeper slopes. Slopes that are steeper than two feet horizontal for every vertical foot (2:1) are typically poor candidates for successful revegetation. Flatter slopes require a wider easement and more excavation and disturb a greater area, all of which will need to be addressed during design.

- ***Topsoil Salvage***
  Once constructed, most cut and fill slopes are sterile; that is, they are devoid of organic material, including mycorrhizal fungi which form beneficial associations with plant roots to aid in the uptake of water and nutrients. Organic matter and native micorrhizae are typically found in the topsoil of undisturbed soils. The salvage of topsoil and its distribution over finished slopes form an important component of successful revegetation of those slopes.
  - The top 12 to 18 inches of soil, roots, detritus, leaves and small twigs should be removed and stockpiled prior to other soil-disturbing activities.
  - Do not stockpile the salvaged soil higher than five feet in order to avoid "composting", which will kill the microbial organisms.
  - Stockpiled soil will typically be staged at the tops and toes of future cut and fill slopes. Therefore and especially on large slopes, sufficient space must be cleared to allow for topsoil salvage or the contractor must be instructed to transport the topsoil to a staging area for subsequent relocation.
  - Following construction of the slope or during construction of large cut slopes, the salvaged soil is dragged across the slope, leaving a topdressing over the face of the slope.
  - Where the volume of salvaged topsoil will be insufficient to dress large slopes, the design team may consider the use of commercially available inoculums or compost in order to introduce beneficial mycorrhizae.
  - During design, the landscape architect and BLM/FS representative should meet in the field to review the project site for the presence of invasive or noxious weed species (see Chapter 11). Where these are encountered, steps must be taken for their removal prior to the onset of construction. If located outside of an approved easement, responsibility for addressing weed removal may require additional coordination.

- ***Slope Finishes***
  - **Slope Roughening**: In order to create a proper environment for successful revegetation, it is imperative that the finish soil surface remains loose and friable, Figure 7.4, so that applied seed may take root. It is also important that the slope finish remain "rough" and uncompacted to allow precipitation to infiltrate. Note that these slope conditions typically require close coordination between two contractors: (1)

Figure 7.4 Slope roughening keeps the soil loose and friable so that seeds may take root.

the earthmoving contractor who performs grading and (2) the revegetation contractor who applies seed and mulch. If the soil of a completed slope becomes crusted over (usually from rainfall), it is imperative that that slope be ripped again before the seeding.

- **Mini-Benching:** In general, cut slopes are more difficult to successfully revegetate than are fills. In part this is due to the fact that even when ripped, cut slopes remain compacted below that layer of ripped soil. Therefore, instead of absorbing precipitation (which accelerates the revegetation process), cut slopes tend to shed rainfall. As discussed in greater detail in Chapter 4, one means of addressing this problem is the construction of serrated slopes or mini-benches, Figure 7.5.

- ***Seeding***

  Large highway projects may result in the disturbance of several hundred acres of soil. In order to address reclamation at that scale in a cost effective and timely fashion, soils that have been disturbed during construction are typically reclaimed by applying compost, fertilizers and soil amendments, seed, Figure 7.6, and mulch. The following concerns should be considered during the design process:
  - The designer should review both ADOT Standard and Stored Specifications prior to writing Special Provisions for seed requirements.
  - Successful revegetation greatly depends on slope ratios and on preparation of the finish grade prior to applying seed. Refer to Chapter 4 for more information.
  - **Compost:** As discussed above, microbial activity is critical to successful revegetation. In association with topsoil salvage, compost can serve to encourage microbial activity. Compost must be sufficiently mature, meaning that the carbon to nitrogen (C:N) ratio should be low (20:1). A high C:N ratio (100:1) will lead to nitrogen depletion. Compost should typically be applied at 12-20 cubic yards per acre and tilled into the soil before seed is applied. The project contract documents should provide direction regarding laboratory analysis, composition and application rates.
  - **Fertilizers and soil amendments:** Inorganic fertilizers and soil amendments should be tilled into the soil before seed is applied and should be described in the project contract documents. In general, nitrogen (N) and phosphorus (P) should be applied in a slow-release, insoluble form. Incorporation of fertilizers into the soil and the use of slow-release, low solubility forms minimize the movement of nitrogen and phosphorus into waterways and aquifers.
  - **Seed mixes:** Seed is typically applied as a mix of several species:
    - Seed mixes should reflect the plant species that are native to the project area. When a project includes several bio-zones, appropriate seed mixes should be developed for each zone.
    - Two seed mixes where appropiate are prepared for ADOT highway projects: one mix to be applied to areas within the clear (or recovery) zone; the other mix to be applied to areas outside of the clear zone. Tree species are

Figure 7.5 Mini benching allows for more water retention thus giving seeds a better chance to take hold.

Figure 7.6 Successful revegetation using seeding on a cut slope.

typically not included in the clear zone mix (see Chapter 4 for a description of clear zone).

- The designer should ensure that desired seed mix species will be commercially available at time of construction. The development of the seed mix should be an iterative process between the landscape architect, seed suppliers, and BLM/FS representatives.
- Seed mixes should include species that can be relied on to establish themselves under difficult conditions and should allow for both immediate and long-term stabilization. Typically, a seed mix includes both annual and perennial species of wildflowers as well as grasses, shrubs and trees. Seed mixes should include a mix of warm and cool season species reflecting seasonal rainfall patterns.
- The project contract documents should clearly spell out requirements concerning legal certification to avoid contamination from noxious or invasive species and to confirm viability. A seed lot labeled as certified free of noxious weeds at time of testing is an insufficient certification because the seed may still contain other weed seed. Tags and seed laboratory test results for each seed species furnished by the contractor must be provided to the field inspector prior to mixing. See Chapter 11 for information regarding noxious and invasive weeds.
- Consult with local BLM/FS resource personnel regarding both desirable and undesirable plant species that should be included in or excluded from the seed mix. There may be plant species that are not included on State or Federal noxious weed lists that are considered invasive species to the project area.

- **Seed application rates:** The designer will need to describe application rates in Pure Live Seed (PLS) in pounds per acre in the project contract documents. The designer will need to review the number of live seed per pound for each species in order to determine application rates. ADOT's Roadside Development Section can assist with this effort.
- **Seed application techniques:** Seed is typically applied by drill or by hydraulic equipment (hydroseeder), Figure 7.7.
  - Drilling ensures positive seed/soil contact, but requires slopes flatter than 3:1 and that are free of rock to be effective. Also, seed drills may not be able to apply some types of seed species that are very large, very small, with long awns or which tends to clump.
  - Hydroseeding, is more commonly employed on ADOT projects. Seed, tackifier and wood fiber are mixed into a slurry and hydraulically applied to the prepared soil. This method allows for application to steep and rocky slopes or slopes where equipment access is difficult.
- **Mulches:** Once applied to the prepared soil, seed should be covered with mulch in order to provide protection from predation, solar exposure and erosion. In order to be effective, mulch needs to remain in place following its application. The longer the mulch remains in place, the greater the chances for successful seed germination and revegetation. The project contract documents should state the length of time that applied mulch should be maintained in place by the contractor. Mulches are generally one of two types:
  - Straw. Straw, Figure 7.8, provides superior erosion control and insulation against heat and moisture loss. It is

Figure 7.7 Slope on the right has been hydroseeded.

Figure 7.8 Straw provides superior erosion control and insulation against heat and moisture loss.

Figure 7.9 Tackifier is used to stabilize the applied mulch on a slope.

typically blown onto the prepared soil by mechanical means, although it may be modified for hydraulic application. (Hydraulic equipment can generate pressure sufficient to apply material over greater distances than can mechanical equipment. The ability to apply seed and mulch over significant distances can be important when addressing large slopes.) The project contract documents should clearly state certification requirements for straw to avoid contamination from noxious or invasive weed species

- Wood fiber. Wood fiber does not provide erosion control or moisture retention as effectively as straw. Wood fiber is typically applied by hydraulic equipment; therefore, it may be applied over greater distances than straw. On roughened slopes, it may be necessary to apply mulch from more than one angle in order to avoid "shadowing."
  - **Tackifier:** Tackifier, Figure 7.9, is used to stabilize the applied mulch on the slope. When straw mulch is used, the tackifier is applied in combination with a small amount of wood fiber to hold the straw in place. When wood fiber is used as mulch, tackifier and wood fiber are applied at the same time. There are several different types of tackifier and the performance of most types will vary with project weather conditions. The project contract documents should provide the contractor with the appropriate methods and materials to be used.
  - **Mobilization**: Seed application requires specialized equipment that will be required at the job site according to the general contractor's earthmoving schedule. For large projects, the seeding contractor may be required to mobilize his equipment numerous times. The project contract documents should clearly describe the maximum area of disturbed soil that will be permitted to remain unseeded for a maximum length of time. For large projects, the project contract documents should include a separate bid item for a specific number of mobilizations.
  - **NOT requirements**: As described in greater detail in the *ADOT Erosion and Pollution Control Manual*, ADOT and the contractor must comply with the ADEQ/EPA Statewide Permit regarding stormwater permits and provide to ADEQ or EPA a Notice of Termination (NOT) at the conclusion of construction. For most ADOT projects on BLM and FS lands, successful revegetation is an essential component of final stabilization. The project contract documents should provide requirements regarding the minimum amount of perennial vegetative cover that is required prior to filing the NOT. The ADOT methodology for determining final stabilization may be found at the ADOT Stormwater Program website listed at the conclusion of this chapter.

Native Plant Salvage

Native vegetation should be considered for salvage. Issues related to plant salvage include:

- Cost: Operations related to meeting ADOT-approved levels of plant salvage and replanting are described in ADOT Roadside Development's

website listed at the conclusion of this chapter.

- Appropriate species: The design team should review the requirements of Arizona Native Plant Laws, 404 Permit and NEPA documents as well as discuss the subject with appropriate BLM/FS representatives. In addition, the design team should consider salvaging species that exhibit difficulty in regenerating naturally or are important for local wildlife. Salvaged species must be able to sustain themselves at the conclusion of the Establishment Period (see below).
- Appropriate quantities: The design team should review existing conditions in the project area and seek to establish similar conditions in the right of way easement.
- Contractor access: Salvage operations typically occur prior to earthwork. Therefore, the salvage contractor may need to construct his own pioneer roads to gain access to the desired plants (and boulders—see below). For projects in areas with significant topography, this access may be a constructability issue and affect salvage costs.
- Once-move: Salvaged plants may be once-moved: they are transplanted from their original growing locations into areas that will remain outside the limits of disturbance. This technique is appropriate for plants that do not transplant easily, such as large saguaro cacti, Figure 7.10. Temporary irrigation will be required for these relocated plants.
- Temporary nurseries: Salvaged plants are typically relocated to an on-site nursery, Figure 7.11, (or series of nurseries). Landscape contractors typically want to minimize the distance that they need to travel when transporting plants. Therefore, the design team should attempt to identify appropriate nursery sites within the project limits. These sites will require regrading and revegetating following completion of the project. Note that while in temporary nurseries, salvaged plants will require irrigation.
- Container sizes: Consider utilizing a variety of sizes in order to maximize chances for survival and to develop a varied plant palette.
- Appropriate locations:
  - Transplant locations should be selected based on both natural resource and aesthetic concerns.
  - Salvaged plants can be intermixed with plants that have been protected in place during construction.
  - Salvaged plants can be located to screen undesirable views.
  - Salvaged plants can be located in more highly visible areas, Figure 7.12, such as cut/fill transitions and parking areas.
  - Salvaged plants can be concentrated in order to create resource islands that can provide seed for surrounding areas.
  - Plants should not be located in areas where they will interfere with maintenance activities.
  - Establishment Period: A part of the project contract documents, the Establishment Period describes contractor obligations regarding maintenance and survival rates for transplanted plants for a given length of time (generally two years following installation). Salvaged plants will typically require a temporary irrigation system when transplanted into their final locations. Smaller plant species may also require

Figure 7.10 Salvaged plants may be once-moved, such as large cacti.

Figure 7.11 Salvaged plants are typically relocated to an on-site nursery.

temporary protection from predation. All equipment should be removed at the conclusion of the Establishment Period.

Figure 7.12 Salvaged plants can be located in more highly visible areas.

Container-Grown Stock

Container-grown stock typically consists of trees or large shrubs species that are native to the project area and that are supplied by an approved nursery. They can be installed in required quantities where the design team determines that more rapid revegetation of disturbed slopes is needed (for example: bridge embankment slopes adjacent to natural drainages that serve as wildlife corridors).

- The proper container size is critical for the survival of container-grown stock in arid environments. A typical diameter to height container ratio should be a minimum of 1:4.
- Species that are native to the project area should be selected growing. Seed should be gathered from sources as close to the project area as possible.
- Container stock will require temporary irrigation until established. This Establishment Period is typically two years.
- Container stock will typically require protection from predation from wildlife during the Establishment Period. Protective sleeves and fencing are commercially available for this purpose. Sleeves may be removed at the end of the landscape establishment period or remain in place until desired as defined in the project contract documents.

Live Cuttings and Pole Plantings

Dormant branches cut from riparian trees (cottonwood and willow) may be directly planted into moist riparian soils where rooting and establishment can take place.

- Cuttings should be gathered and planted in late winter/early spring before trees leaf out.
- Branches may be 1-4” diameter and should be stripped of leaves.
- Install branches with same orientation as original sap flow.

Noxious and Invasive Vegetation

If allowed to become established, noxious and invasive vegetation, Figure 7.13, pose significant economic and ecological threats to the long-term biological health of an area. The term “noxious weed” has legal ramifications: both the State of Arizona and the federal government publish lists of noxious weed species (see Chapter 11 for links to state and federal websites listing noxious weeds). An “invasive weed” is one that grows and spreads rapidly, replacing desirable native plants. Arizona Executive Order 2005-09 mandates that the state take an active role in the detection and control of invasive species. These laws and regulations were enacted to prevent damage to natural resources resulting from the establishment of noxious and invasive vegetation.

Figure 7.13 Noxious and invasive weeds pose a threat to the biological health of an area.

Noxious and invasive plants species are frequently problematic because they are typically able to quickly and efficiently colonize disturbed areas. Newly constructed highways and their associated disturbed slopes provide abundant opportunities for these plant species to establish colonies and spread into surrounding landscapes. Often roadways provide “linear routes” for invaders by conveying them along the entire disturbed area into new landscapes. It is critical that efforts be made to minimize the chances for the introduction and

establishment of noxious and invasive weeds in highway corridors:

- Before ground-disturbing activities begin, inventory and prioritize weed infestations for treatment in project operation areas and along access routes. Control weeds as necessary, as early as possible in the project planning process. Map areas in the project plans infested with noxious or invasive weeds and develop appropriate methods for control which meet BLM/FS requirements.
- Project staging areas should be free of noxious or invasive weeds. Where these weed species are present, a control plan should be developed in coordination with BLM/FS.
- Equipment transported from outside of the BLM/FS district should be cleaned prior to entering the project area. If necessary and in consultation with BLM/FS, identify site(s) where equipment can be cleaned. All mud and plant debris should be removed and contained as directed in ADOT's *Erosion and Pollution Control Manual*.
- If operating in areas infested with weeds, clean all equipment before leaving the project site as described above.
- Inspect material sources on site and ensure that they are weed-free before use and transport. Treat weed-infested sources for eradication: strip and stockpile contaminated material for proper disposal. Document and closely inspect those areas where treated soils are used during construction to ensure that any weeds transported to the site are promptly detected and controlled.
- Maintain stockpiled material in a weed-free condition.

Figure 7.14 Salvaged boulders should be placed in groups for a more naturalistic setting.

Existing Boulders

Where they exist in the project area, consider salvaging boulders from the surface prior to earthmoving activities. These should be moved using slings or other equipment that won't mar the weathered surfaces. Similar to salvaged plant material described above, the project contract documents should provide direction regarding final locations of the material. In general, boulders placed in groups, Figure 7.14, appear more naturalistic than when placed alone.

7.4 CONSTRUCTION

As discussed throughout this manual, the integration of the highway into the surrounding landscape is of central concern to both BLM and FS. The successful revegetation of constructed slopes is a critical component of this integration. In addition, NEPA and other environmental documents may provide specific requirements requiring restoration of the project area. Finally, as will be described in Chapter 8, ADOT is legally obligated to revegetate and stabilize soils disturbed by construction. In general, for projects constructed on BLM and FS lands, restoration and revegetation is achieved through seeding. Therefore, the successful seeding of soils disturbed by construction is central to the success of the overall project. It is crucial during construction that field staff closely attend to the project contract documents as they relate to revegetation. Issues as varied as the condition of the finished grade (compacted or loose, crusted or friable), the timing of seed applications (for large cut and fill slopes), the inspection of seed mixes, tackifiers and composts and the review of proper application techniques will all affect the successful restoration of the project.

7.5 ADDITIONAL RESOURCES

ADOT Roadside Development Section:
http://www.azdot.gov/Highways/RdwyEng/RoadsideDevelopment/index.asp

ADOT Stored Specifications:
http://azdot.gov/highways/cns/CNS_Stored_specs.asp

ADOT Methodology for Determining Final Stabilization:
http://www.azdot.gov/Highways/RdwyEng/RoadsideDevelopment/ADOTMethodologyforDeterminingFinalStabilization/ADOT_Methodology_V5_Propo_31Jan06.pdf

Visual Impact Assessment for Highway Projects:
http://www.contextsensitivesolutions.org/content/reading/visual-impact-2/

ADOT Erosion and Pollution Control Manual:
http://www.azdot.gov/adot_and/storm_water/stormwater.asp

State Noxious Weed List:
http://www.azda.gov/PSD/quarantine5.htm

Federal Noxious Weed List: **http://plants.usda.gov/java/noxious?rptType=Federal**

Executive Order 13112:
http://www.invasivespeciesinfo.gov/laws/execorder.shtml